In the Specification

Kindly replace paragraphs [0001] through [0011] with the following:

Related Application

This is a §371 of International Application No. PCT/JP2004/018776, with an international filing date of December 9, 2004 (WO 2005/056856 A1, published June 23, 2005), which is based on Japanese Patent Application No. 2003-414336, filed December 12, 2003.

Technical Field

The ~~present~~ invention relates to steels suitably used for structural parts of automobiles and a method for producing the same. ~~In particular, the present invention~~The disclosure also relates to improvements in formability, fatigue endurance after quenching, low temperature toughness, and resistance for hydrogen embrittlement of steels used as materials for forming and quenching suspension arms and axle beams. ~~In the present invention, the~~The term "steel" includes steel strips and steel tubes.

Background ~~Art~~

~~Patent Document 1~~JP 7-74382 discloses ~~a technique on~~ a method for producing hot-rolled steels for body-reinforcing electric resistance welded tubes by induction hardening. The technique disclosed in ~~Patent Document 1~~JP 7-74382 can produce body-reinforcing electric resistance welded tubes required to have high strength, such as door guard beams and bumper reinforcements, which have high energy absorbability due to induction hardening. However, ~~the~~that technique has the problem of failing to achieve formability, fatigue endurance after quenching, and low temperature toughness required for suspension and chassis members.

~~Patent Document 2~~JP 2000-248338 discloses ~~a technique on~~ steel sheets for induction hardening and induction-hardened reinforcing members, which have excellent hardenability,

hardened portions with toughness, and excellent high energy absorbability, and a method for producing these. The technique disclosed in ~~Patent Document 2~~JP 2000-248338 can produce body-reinforcing members, such as center pillars and bumper reinforcements, which have excellent high impact energy absorbability due to induction hardening. However, ~~this~~that technique has the problem of failing to achieve fatigue endurance after quenching and low temperature toughness which are required for suspension and chassis members.

~~Patent Document 3~~JP 2605171 discloses ~~a technique on~~ high toughness electric resistance welded tubes for heat treatment which can impart high strength and toughness by heat treatment. The technique disclosed in ~~Patent Document 3~~JP 2605171 can produce automobile door reinforcements made from steel tubes by, for example, quenching after induction heating, the reinforcements having high strength and excellent low temperature toughness. However, ~~this~~that technique has the problem of failing to achieve fatigue endurance, resistance for hydrogen embrittlement, and corrosion fatigue endurance required for suspension and chassis members.

~~Patent Document 4~~JP 2000-248331 discloses ~~a technique on~~ low alloyed steel sheets having excellent properties of heat treatment by irradiation of a high energy density beam, high fatigue endurance after quenching, and high workability. The technique disclosed in ~~Patent Document 4~~JP 2000-248331 can improve local fatigue endurance. However, ~~this~~that technique has the problem of failing to secure fatigue endurance required over the wholes of suspension and chassis members and to achieve resistance for hydrogen embrittlement and corrosion fatigue endurance required for these members.

~~Patent Document 5~~WO 02/070767 A1 discloses a technique on electric resistance welded tubes for hollow stabilizers which have excellent workability. The technique disclosed in ~~Patent Document 5~~WO 02/070767 A1 can produce electric resistance welded tubes for hollow stabilizers

having homogeneous metal structures in electric resistance welded portions and matrix portions and excellent workability due to induction heating and diameter reduction rolling of the electric resistance welded tubes. However, ~~this~~that technique has the problem of failing to achieve fatigue endurance, resistance for hydrogen embrittlement, and corrosion fatigue endurance required for suspension and chassis members.

~~Patent Documents 6, 7, and 8~~JP 3111861, JP 3374659 and JP 2003-138316 disclose ~~techniques on~~ high tension electric resistance welded tubes which have excellent resistance for hydrogen embrittlement. The techniques include increasing tensile strength of steel strips and then forming tubes to produce high tension steel tubes having excellent resistance for hydrogen embrittlement. However, ~~these~~those techniques have the problem of failing to achieve formability and fatigue endurance required for suspension and chassis members.

~~Patent Document 1: Japanese Examined Patent Application Publication No. 7-74382~~

~~Patent Document 2: Japanese Unexamined Patent Application Publication No. 2000-248338~~

~~Patent Document 3: Japanese Patent Publication No. 2605171~~

~~Patent Document 4: Japanese Unexamined Patent Application Publication No. 2000-248331~~

~~Patent Document 5: International Publication No. WO 02/070767 A1 pamphlet~~

~~Patent Document 6: Japanese Patent Publication No. 3111861~~

~~Patent Document 7: Japanese Patent Publication No. 3374659~~

~~Patent Document 8: Japanese Unexamined Patent Application Publication No. 2003-138316~~

~~Disclosure of the Invention~~

~~An object of the present invention is to advantageously resolve the problems of the above-desceried conventional techniques and~~It would therefore be advantageous to provide a steel having excellent formability, excellent fatigue endurance after quenching, excellent low temperature

toughness, excellent resistance for hydrogen embrittlement, and excellent corrosion fatigue endurance ~~which are required~~ for suspension and chassis members, and a technique for producing the steel.

~~In the present invention, the term "excellent formability" means that a tensile test using a specimen of JIS No. 12 shows an elongation El of 20% or more. The term "excellent fatigue endurance after quenching" means that the maximum stress amplitude σf causing no fatigue failure in a completely reversed plane bending fatigue endurance test (stress ratio: −1.0) is 450 MPa or more. The term "excellent low temperature toughness" means that the fracture appearance transition temperature vTrs in a Charpy impact test (specimens: 1/4 size, 2 mm V-notch) is -40°C or less. The term "excellent resistance for hydrogen embrittlement" means that the failure time in a four-point bending test (load stress: 1180 MPa) in 0.1N hydrochloric acid is 200 hours or more. The term "excellent corrosion fatigue endurance" means that the fatigue life in a completely reversed plane bending fatigue test (stress ratio: −1) after a corrosion test is 1/2 or more of the number of cycles in a case without corrosion.~~

~~Means for Solving the Problems~~

~~In order to obtain a steel being excellent in all the conflicting properties, such as formability, fatigue endurance after quenching, low temperature toughness, resistance for hydrogen embrittlement, and corrosion fatigue endurance, the inventors conducted systematic experimental study using various chemical compositions, microstructures before quenching, quenching methods and conditions, etc. As a result, it was found that when a chemical composition, strip production conditions, material steel tube production conditions, and a structure before quenching are determined in specified limited ranges, a steel simultaneously satisfying all the formability, fatigue endurance after quenching, low temperature toughness, resistance for hydrogen embrittlement, and~~

~~corrosion fatigue endurance, which are required for suspension and chassis members, can be obtained.~~

~~The present invention has been completed on the basis of this finding and additional study. Namely, the gist of the present invention is as follows:~~

Summary

(1) A steel for structural parts of automobiles having excellent formability, fatigue endurance after quenching, low temperature toughness, and resistance for hydrogen embrittlement is disclosed, the steel having a composition containing, by mass, 0.18 to 0.29% of C, 0.06 to 0.45% of Si, 0.91 to 1.85% of Mn, 0.019% or less of P, 0.0029% or less of S, 0.015 to 0.075% of sol. Al, 0.0049% or less of N, 0.0049% or less of O, 0.0001 to 0.0029% of B, 0.001 to 0.019% of Nb, 0.001 to 0.029% of Ti, 0.001 to 0.195% of Cr, and 0.001 to 0.195% of Mo so that the carbon equivalent Ceq defined by the following equation (1):

$$Ceq = C + Mn/6 + Si/24 + Ni/40 + Cr/5 + Mo/4 + V/14 \qquad (1)$$

(wherein C, Mn, Si, Ni, Cr, Mo, and V represent the contents (% by mass) of the respective elements) satisfies a value of 0.4 to less than 0.58, and the total x of multiplying factors including that for B according to Grossmann satisfies a value of 1.2 to less than 1.7, the balance being substantially composed of Fe, and the steel having a structure in which the ferrite grain diameter df corresponding to a circle is 1.1 μm to less than 12 μm, and the ferrite volume fraction Vf is 30% to less than 98%.

(2) The steel (1) for structural parts of automobiles further containing, by mass, at least one selected from 0.001 to 0.175% of Cu, 0.001 to 0.145% of Ni, and 0.001 to 0.029% of V in addition to the above composition[[:]].

(3) The steel (1) or (2) for structural parts of automobiles further containing 0.0001 to 0.0029% by mass of Ca in addition to the above composition.

(4) A method for producing a steel for structural parts of automobiles having excellent formability, fatigue endurance after quenching, low temperature toughness, and resistance for hydrogen embrittlement, the method including heating a steel slab at 1160°C to 1320°C, hot-finish-rolling the steel slab at a finisher delivery temperature of 750°C to 980°C, and then coiling the not-rolled steel at a coiling temperature of 560°C to 740°C after slow cooling for a time of 2 seconds or more to produce a hot-rolled steel strip, wherein the steel slab has a composition containing, by mass, 0.18 to 0.29% of C, 0.06 to 0.45% of Si, 0.91 to 1.85% of Mn, 0.019% or less of P, 0.0029% or less of S, 0.015 to 0.075% of sol. Al, 0.0049% or less of N, 0.0049% or less of O, 0.0001 to 0.0029% of B, 0.001 to 0.019% of Nb, 0.001 to 0.029% of Ti, 0.001 to 0.195% of Cr, and 0.001 to 0.195% of Mo so that the carbon equivalent Ceq defined by the following equation (1):

$$Ceq = C + Mn/6 + Si/24 + Ni/40 + Cr/5 + Mo/4 + V/14 \qquad (1)$$

(wherein C, Mn, Si, Ni, Cr, Mo, and V represent the contents (% by mass) of the respective elements) satisfies a value of 0.4 to less than 0.58, and the total x of multiplying factors including that for B according to Grossmann satisfies a value of 1.2 to less than 1.7, the balance being preferably composed of Fe.

(5) The method (4) for producing a steel for structural parts of automobiles, wherein the steel slab further contains, by mass, at least one selected from 0.001 to 0.175% of Cu, 0.001 to 0.145% of Ni, and 0.001 to 0.029% of V in addition to the above composition.

(6) The method (4) or (5) for producing a steel for structural parts of automobiles, wherein the steel slab further contains 0.0001 to 0.0029% by mass of Ca in addition to the above composition.

(7) A method for producing a steel tube for structural parts of automobiles having excellent formability, fatigue endurance after quenching, low temperature toughness, and resistance for hydrogen embrittlement, the method including making a tube from the hot-rolled steel strip by electric resistance welded tube making with a width reduction of hoop of 8% or less, the hot-rolled steel strip being produced by any one of the methods (4) to (6) and used as a raw material immediately after hot rolling or after pickling of the hot-rolled steel strip.

Kindly replace paragraphs [0016] through [0029] with the following:

~~Best Mode for Carrying Out the Invention~~Detailed Description

In the text below, the term "excellent formability" means that a tensile test using a specimen of JIS No. 12 shows an elongation El of 20% or more. The term "excellent fatigue endurance after quenching" means that the maximum stress amplitude σf causing no fatigue failure in a completely reversed plane bending fatigue endurance test (stress ratio: -1.0) is 450 MPa or more. The term "excellent low temperature toughness" means that the fracture appearance transition temperature vTrs in a Charpy impact test (specimens: 1/4 size, 2 mm V-notch) is -40°C or less. The term "excellent resistance for hydrogen embrittlement" means that the failure time in a four-point bending test (load stress: 1180 MPa) in 0.1N hydrochloric acid is 200 hours or more. The term "excellent corrosion fatigue endurance" means that the fatigue life in a completely reversed plane bending fatigue test (stress ratio: -1) after a corrosion test is 1/2 or more of the number of cycles in a case without corrosion.

The reasons for ~~limiting~~selecting the chemical component ranges ~~of a steel of the present invention~~ will be described. In the composition below, "% by mass" is simply shown by "%".

C: 0.18 to 0.29%

C is an element necessary for securing fatigue endurance after quenching. However, at a C content of less than 0.18%, it is difficult to secure desired fatigue endurance, while at a C content exceeding 0.29%, resistance for hydrogen embrittlement degrades. Therefore, the C content is ~~limited to~~in a range of about 0.18% to about 0.29%. The C content is preferably 0.18% to 0.24%.

Si: 0.06% to 0.45%

Si is an element for accelerating ferrite transformation in a hot rolling step. ~~In the present invention, in order to~~To secure a ferrite volume fraction necessary for securing formability before quenching, the Si content must be 0.06% or more. At a Si content of less than 0.06%, the ferrite volume fraction becomes insufficient and formability degrades, while at a Si content exceeding 0.45%, the electric resistance weldability degrades, and the low-temperature toughness after quenching also degrades. Therefore, the Si content is ~~limited to~~in a range of about 0.06% to about 0.45%. The Si content is preferably 0.15% to 0.35%.

Mn: 0.91% to 1.85%

Mn is an element for suppressing ferrite transformation in a quenching step. ~~In the present invention, in order to~~To secure fatigue endurance after quenching which is required for a more than 90% tempered martensite structure, the Mn content must be 0.91% or more. At a Mn content of less than 0.91%, a ferrite structure appears in a surface layer during quenching to fail to achieve desired fatigue endurance. On the other hand, at a Mn content exceeding 1.85%, the martensite transformation temperature (Ms point) of the steel decreases, and self-tempering (precipitation of micro carbide) of martensite in a quenching step is suppressed to increase the quenching strain of a quenched member and degrade resistance for hydrogen embrittlement. Therefore, the Mn content is

~~limited to~~in a range of about 0.90% to about 1.85%. The Mn content is preferably over about 1.0% to about 1.6%.

P: 0.019% or less

P is an element which segregates at austenite boundaries during quench and heating or segregates at boundaries between cementite and ferrite matrixes during cementite precipitation in a step of tempering martensite, thereby degrading low temperature toughness and resistance for hydrogen embrittlement. At a P content exceeding 0.019%, the adverse effect becomes significant. Therefore, the P content is ~~limited to~~about 0.019% or less. The P content is preferably about 0.014% or less.

S: 0.0029% or less

S remains as an elongated MnS inclusion in steel to decrease formability, low temperature toughness, and fatigue endurance. In addition, S functions as an anode in corrosion under coating to accelerate local corrosion and entrance of hydrogen, thereby significantly decreasing resistance for hydrogen embrittlement and corrosion fatigue endurance. At a S content exceeding 0.0029%, the adverse effect becomes significant. Therefore, the upper limit of the S content is about 0.0029% and preferably about 0.0020%.

Sol. Al: 0.015% to 0.075%

Al is a deoxidizing element in steel making and an element for suppressing the growth of austenite grains in a hot-rolling step. ~~In the present invention, in order to~~To obtain a desired structure and grain diameter in combination with hot-rolling conditions, the sol. Al content must be 0.015% or more. At a sol. Al content of less than 0.015%, the above-described effect is not exhibited, while at a sol. Al content exceeding 0.075%, the effect is saturated, and an oxide inclusion

is increased to degrade the production properties and fatigue endurance. Therefore, the sol. Al content is ~~limited to~~about 0.015% to about 0.075%.

N: 0.0049% or less

N bonds to Ti and precipitates as TiN, but a variation thereof becomes a variation in surplus dissolved Ti, resulting in variations in strength and properties. Therefore, the content range must be strictly specified. At a N content exceeding 0.0049%, low temperature toughness degrades due to the precipitation of excessive TiN. Therefore, the upper limit of the N content is about 0.0049%.

O: 0.0049% or less

O mainly remains as an inclusion in steel and decreases formability and fatigue endurance. At an O content exceeding 0.0049%, the adverse effect becomes significant. Therefore, the upper limit of the O content is about 0.0049%. The O content is preferably about 0.0020% or less.

B: 0.0001% to 0.0029%

B is an element necessary for securing hardenability without degrading resistance for hydrogen embrittlement. This effect is exhibited at a B content of 0.0001% or more. On the other hand, at a B content exceeding 0.0029%, the resistance for hydrogen embrittlement degrades. Therefore, the B content is ~~limited to~~about 0.0001% to about 0.0029%. The B content is preferably about 0.0008% to about 0.0018%.

Nb: 0.001% to 0.019%

Nb is an element which can make a fine structure in a hot-rolling step to form a desired structure and grain diameter due to a synergistic effect with AlN and which can suppress the growth of austenite grains during heating after forming to improve low temperature toughness after quenching. These effects are exhibited even at a low content of 0.001% or more, but formability

before quenching degrades at a content exceeding 0.019%. Therefore, the Nb content is ~~limited to~~in a range of about 0.001% to about 0.019%.

Ti: 0.001% to 0.029%

Ti bonds to N and preferentially precipitates as TiN to effectively leave dissolved B, thereby contributing to the securement of hardenability. Furthermore, Ti decreases dissolved N to contribute to the securement of formability before quenching. These effects are exhibited at a content of 0.001% or more, but the formability before quenching and low temperature toughness degrade at a content exceeding 0.0029%. Therefore, the Ti content is ~~limited to~~in a range of about 0.001% to about 0.029%.

Cr: 0.001% to 0.195%

Cr is an element for improving hardenability and is contained for complementing the functions of Mn and B in the present invention. Also, a decrease in the Ms point due to the addition of Cr is lower than that by Mn, and thus Cr can suppress quenching strain. In addition, Cr hardly co-segregates with P at an austenite boundary during quenching and heating, and thus the addition of Cr has a small adverse effect on the resistance for hydrogen embrittlement. These effects are expressed at a content of 0.001% or more, but formability before quenching degrades at a content exceeding 0.195%. Therefore, the Cr content is about 0.001% to about 0.195%.

Mo: 0.001% to 0.195%

Mo is an element for improving hardenability to complement the functions of Mn and B and decrease the potential of C in steel, thereby suppressing surface decarbonization during quenching and heating and significantly improving fatigue endurance after quenching. These effects are expressed at a content of 0.001% or more, but formability before quenching degrades at a content exceeding 0.195%. Therefore, the Mo content is about 0.001% to about 0.195%.

Kindly replace paragraphs [0032] through [0034] with the following:

Cu: 0.001% to 0.175%

Cu is an element having the effect of suppressing the progress of corrosion by concentration as a metal element in a surface layer, particularly in a MnS anode portion, with the progress of corrosion, and the effect of suppressing the entrance of hydrogen into steel to improve resistance for hydrogen embrittlement. Cu may be added according to demand. At a content of 0.001% or more, these effects are expressed, but, at a content exceeding 0.175%, the problem of producing surface scars due to melted Cu during hot rolling increases. Therefore, the Cu content is preferably <u>about</u> 0.001% to <u>about</u> 0.175%.

Ni: 0.001% to 0.145%

Ni is an element having the effect of improving a strength-toughness balance and the effect of improving resistance for hydrogen embrittlement by concentration in a surface layer, and Ni may be contained according to demand. At a content of 0.001% or more, these effects are expressed, but, at a content exceeding 0.145%, austenite-ferrite transformation is suppressed during hot rolling, thereby failing to obtain a desired structure and decreasing formability before quenching. Therefore, the Ni content is preferably <u>about</u> 0.001% to <u>about</u> 0.145%.

V: 0.001% to 0.029%

V is an element having the function to complement the effect of Nb and may be contained according to demand. At a content of 0.001% or more, this effect is expressed, but, at a content exceeding 0.029%, formability before quenching degrades. Therefore, the V content is preferably <u>about</u> 0.001% to <u>about</u> 0.029%.

Kindly replace paragraphs [0036] through [0037] with the following:

Ca: 0.0001% to 0.0029%

Ca is an element which precipitates as granular CaS in steel to decrease the amount of an elongated MnS inclusion, thereby improving formability, low temperature toughness, fatigue endurance, resistance for hydrogen embrittlement, and corrosion fatigue endurance, and Ca may be contained according to demand. At a content of 0.0001% or more, this effect is expressed, but, at a content exceeding 0.0029%, the adverse effect of a CaO inclusion on these properties becomes significant. Therefore, the Ca content is preferably about 0.0001% to about 0.0029%.

~~In the present invention, the~~The above-described components are contained in the respective above-descried ranges so that the carbon equivalent Ceq defined by the following equation (1):

$$Ceq = C + Mn/6 + Si/24 + Ni/40 + Cr/5 + Mo/4 + V/14 \qquad (1)$$

(wherein C, Mn, Si, Ni, Cr, Mo, and V represent the contents (% by mass) of the respective elements) satisfies a value of 0.4 to less than 0.58, and the total x of multiplying factors including that for B according to Grossmann satisfies a value of 1.2 to less than 1.7.

Kindly replace paragraph [0043] with the following:

Total x of multiplying factors including that for B according to Grossmann: 1.2 to less than 1.7

The multiplying factors according to Grossmann are material parameters required to be controlled for achieving the desired formability of an original sheet, hardness after quenching, and fatigue endurance. ~~In the present invention, as~~As the multiplying factors according to Grossmann, for example, the values for the respective elements described in Table 3 of Iron & Steel Material Science, Leslie, Maruzen, pp. 402-405 are used. In other words, the value of each element is determined according to the content thereof, and the total x of the elements is determined. As the multiplying factor for C among the multiplying factors according to Grossmann, the value for ASTM

grain No. 7 is used. When dissolved B is contained in an amount larger than the N equivalent with consideration of fixing by TiN, the multiplying factor for B which has not been specified is considered as 0.2 regardless of the content.

Kindly replace paragraphs [0046] through [0047] with the following:

The steel ~~of the present invention~~ has a structure in which the ferrite grain diameter df corresponding to a circle is 1.1 μm to less than 12 μm, and the ferrite volume fraction Vf is 30% to less than 98%.

Ferrite grain diameter df corresponding to a circle: 1.1 μm to less than 12 μm

The microstructure of a raw material (steel) before quenching is an important material parameter for securing excellent formability, high fatigue endurance after quenching, and the like. When the ferrite grain diameter df corresponding to a circuit is less than 1.1 μm, desired formability cannot be secured, and a portion where the thickness is locally decreased becomes a stress concentration portion, thereby greatly decreasing fatigue endurance after quenching. On the other hand, when the df is 12 μm or more, particularly the hardenability of a raw material surface decreases, and thus fatigue endurance greatly decreases. Therefore, the ferrite grain diameter df corresponding to a circle of the steel is ~~limited to~~<u>about</u> 1.1 μm to less than <u>about</u> 12 μm.

Kindly replace paragraph [0049] with the following:

~~In the present invention, the~~<u>The</u> ferrite grain diameter df corresponding to a circle is determined by a method in which the area of each ferrite grain is measured by processing an image of the structure, the area of each ferrite grain is converted to a diameter corresponding to a circle, and the obtained ferrite grain diameters corresponding to a circle are averaged. Like the steel used in the present invention, a material having hardenability contains ferrite grains having no regular form.

Therefore, the used ferrite gain diameter is the diameter corresponding to a circuit determined by image processing, not the diameter determined by a cutting method.

Kindly replace paragraph [0052] with the following:

Next, a method for producing a hot-rolled steel strip ~~of the present invention~~ will be described.

Kindly replace paragraphs [0055] through [0056] with the following:

Slab heating temperature: 1160°C to 1320°C

~~In the present invention, elements~~Elements which form slightly soluble carbonitrides, such as Nb, Ti, and the like, are used as essential elements. Therefore, when the slab heating temperature is lower than 1160°C, re-dissolution of carbonitrides becomes locally insufficient, and the ferrite grain diameter after hot rolling partially exceeds 12 μm, thereby decreasing workability before quenching. On the other hand, when the slab heating temperature exceeds 1320°C, the surface quality of final products, such as steel tubes and steel strips, degrades. Therefore, the slab heating temperature is preferably about 1160°C to about 1320°C and more preferably about 1180°C to about 1280°C.

Finisher delivery temperature: 750°C to 980°C

The finisher delivery temperature of hot rolling is an important production parameter which determines the ferrite grain diameter after hot rolling. When the finisher delivery temperature is lower than 750°C, rolling in the ferrite region is caused, and rolling strain remains after coiling to decrease formability before quenching. On the other hand, when the finisher deliver temperature exceeds 980°C, the ferrite grains coarsen, thereby decreasing formability before quenching. Therefore, the finisher delivery temperature is preferably about 750°C to about 980°C and more preferably about 820°C to about 940°C.

Kindly replace paragraph [0058] with the following:

Coiling temperature: 560°C to 740°C

The coiling temperature after the finish of hot rolling is an important production parameter which determines the ferrite volume fraction after hot rolling. When the coiling temperature is lower than 560°C, the desired ferrite volume fraction cannot be obtained, and thus formability before quenching decreases. The higher the coiling temperature within the specified range, the more the formability before quenching is improved. However, when the coiling temperature exceeds 740°C, the C amount in a surface layer significantly decreases, and thus fatigue endurance after quenching degrades. Therefore, the coiling temperature is preferably <u>about </u>560°C to <u>about </u>740°C and more preferably <u>about </u>600°C to <u>about </u>700°C.

Kindly replace paragraph [0060] with the following:

~~In the present invention, by~~<u>By</u> using the hot-rolled steel strip produced by the above-described method, a steel tube for structural parts of automobiles having excellent formability, fatigue endurance after quenching, low temperature toughness, and resistance for hydrogen embrittlement can be produced by electric resistance welded tube making under proper conditions.

Kindly replace paragraphs [0062] through [0064] with the following:

~~In the present invention, the~~<u>The</u> hot-rolled steel strip produced under the above-descried conditions is used as a raw material. The raw material may be used immediately after hot rolling or after descaling by pickling. The raw material immediately after hot rolling or after pickling is preferably formed in a steel tube by electric resistance welded tube making with a width reduction of hoop of 8% or less.

Conditions for electric resistance welded tube making: width reduction of hoop of 8% or less

When the steel strip is formed in a steel tube by continuous roll forming and electric resistance welded tube making, the width reduction of hoop is an important production parameter for securing desired formability before quenching. When the width reduction of hoop exceeds 8%, formability significantly decreases with tube making, and thus necessary formability before quenching cannot be obtained. Therefore, the width reduction of hoop is preferably about 8% or less (including 0%). The width reduction of hoop is defined by the following equation:

Width reduction of hoop (%) = [(width of untreated steel strip) - π {(outer diameter of product - wall thickness of product)}]/[π {(outer diameter of product) - (wall thickness of product)}] × 100

In the method for producing the steel tube ~~of the present invention~~, the raw material is not limited to the hot-rolled steel strip. Of course, a cold-rolled annealed steel strip produced by cold-rolling and annealing the hot-rolled steel strip produced by the above-described method for producing the hot-rolled steel strip, or a surface-treated steel strip further subjected to various surface treatments may be used. Instead of the electric resistance welded tube making, roll forming, press-section closing of a cut plate, or a tube making process combined with cold-, warm-, or hot-reduction, heat treatment, and the like may be used. Furthermore, instead of electric resistance welding, laser welding, arc welding, plasma welding, or the like may be used.

Kindly replace paragraphs [0069] through [0071] with the following:

In all examples ~~of the present invention~~, the elongation El of the untreated tube is 20% or more (JIS No. 12 specimen), the cross-section hardness HV(10) after quenching is 350 to 550, the completely reversed plane bending fatigue endurance σf is 500 MPa or more, the fracture appearance transition temperature vTrs in the Charpy impact test is -40°C or less, the four-point bending failure time in 0.1N hydrochloric acid is 200 hours or more, and the fatigue life in the corrosion fatigue test

is 1/2 or more of the number of cycles of the uncorroded specimen. Therefore, excellent formability, fatigue endurance, low temperature toughness, resistance for hydrogen embrittlement, and corrosion fatigue endurance are exhibited.

On the other hand, in Comparative Example Nos. 5 to 26 in which any one of the steel composition, the carbon equivalent Ceq, and the total x of multiplying factors is out of the desired range ~~of the present invention~~, any one of the formability, fatigue endurance, low temperature toughness, resistance for hydrogen embrittlement, and corrosion fatigue endurance decreases. In Comparative Example Nos. 5, 9, and 14 in which the contents of C, Mn, and B, respectively, in the steel composition are lower than the desired ranges ~~of the present invention~~, the cross-section hardness Hv after quenching is less than 350, and σf after quenching is as low as less than 450 MPa. In Comparative Example Nos. 6, 10, and 15 in which the contents of C, Mn, and B, respectively, in the steel composition exceed the desired ranges ~~of the present invention~~, the four-point bending failure time in 0.1N hydrochloric acid is less than 200 hours, and thus the resistance for hydrogen embrittlement degrades. In Comparative Example No. 7 in which the Si content is lower than the desired range ~~of the present invention~~, the ferrite volume fraction is as low as less than 30%, and the elongation El of the untreated tube is as low as less than 20%. On the other hand, in Comparative Example No. 8 in which the Si content exceeds the desired range ~~of the present invention~~, vTrs is -40°C or higher, and thus low temperature toughness degrades. In Comparative Example Nos. 11, 12, and 13 in which the contents of P, and S, and O, respectively, exceed the desired ranges ~~of the present invention~~, resistance for hydrogen embrittlement, fatigue endurance, or untreated tube El is low.

In Comparative Example Nos. 16, 17, 18, 19, 20, and 21 in which the contents of Nb, Ti, Cr, Mo, Ni, and V, respectively, exceed the desired ranges ~~of the present invention~~, the untreated tube El

is as low as less than 20%, and thus formability degrades. In Comparative Example No. 22 in which the Ca content exceeds the desired range~~of the present invention~~, El, fatigue endurance, low temperature toughness, and resistance for hydrogen embrittlement are low. In Comparative Example Nos. 23 and 25 in which the carbon equivalent Ceq or the total x of multiplying factors exceeds the desired range~~of the present invention~~, the untreated tube El is low, the hardness HV(10) after quenching is as high as over 550, vTrs is high, and resistance for hydrogen embrittlement decreases. In Comparative Example Nos. 24 and 26 in which Ceq or x is lower than the desired range~~of the present invention~~, the ferrite grain diameter corresponding to a circle is as large as 12 μm or more, the hardness HV(10) after quenching is as low as less than 350, and the completely reversed plane bending fatigue endurance σf after quenching is as low as less than 450 MPa.

Kindly replace paragraphs [0075] through [0078] with the following:

In all examples~~of the present invention~~, the elongation El of the untreated tube is 20% or more (JIS No. 12 specimen), the cross-section hardness HV(10) after quenching is 350 to 550, the completely reversed plane bending fatigue endurance σf is 500 MPa or more, the fracture appearance transition temperature vTrs in the Charpy impact test is -40°C or less, the four-point bending failure time in 0.1N hydrochloric acid is 200 hours or more, and the decreased fatigue life in the corrosion fatigue test is 1/2 or more of the number of cycles of an uncorroded specimen. Therefore, excellent formability, fatigue endurance, low temperature toughness, resistance for hydrogen embrittlement, and corrosion fatigue endurance are exhibited.

In Example No. 28 in which the slab heating temperature is lower than the preferred range~~of the present invention~~, Example No. 30 in which the finisher delivery temperature is higher than the preferred range~~of the present invention~~, Example No. 31 in which the finisher deliver temperature is lower than the preferred range~~of the present invention~~, Example No. 33 in which the slow cooling

time on a run out table of hot rolling is shorter than the preferred range~~ of the present invention~~, and Example No. 35 in which the coiling temperature is lower than the preferred range~~ of the present invention~~, the ferrite grain diameter df is larger than 12 μm or the ferrite volume fraction Vf is less than 30%, the elongation of the untreated tube is as low as less than 20% to decrease formability, and the completely reversed plane bending fatigue endurance σf after quenching is as low as less than 450 MPa except in Example No. 33. In Example No. 36 in which the hot-rolled strip coiling temperature is higher than the preferred range~~ of the present invention~~, the elongation El of the untreated tube is as high as 20% or more, but σf is low due to surface decarbonization. In Example No. 38 in which the width reduction of hoop in tube making is higher than the preferred range ~~of the present invention~~ and the coiling temperature is lower than the preferred range~~ of the present invention~~, the elongation El of the untreated tube is as low as 15%, and σf is also low.

In Example No. 40, pickling after hot rolling was omitted; in Example No. 41, the suspension arm of Ø60.5 × 2.6 t was formed and then quenched; in Example No. 42, the steel strip subjected to cold rolling and annealing after hot rolling was formed in an electric resistance welded tube; in Example No. 43, the steel strip was press-formed and then welded (arc, laser, or plasma) to a closed section; in Example No. 44, the steel strip was roll-formed to a closed section and then welded; in Example Nos. 45 and 46, the black plate subjected to Zn or Al plating after quenching was formed in an electric resistance welded tube; in Example No. 47, the electric resistance welded tube was plated with Zn and then quenched; in Examples Nos. 48 and 49, the electric resistance welded tube was subjected to hot- or warm-reduction; in Example No. 50, the untreated tube was heated and quenched during forming; in Example No. 51, shot blasting was performed after quenching; and in Example No. 52, shot peening was performed after quenching. In all Example Nos. 40 to 52 which are desired examples~~ of the present invention~~, the elongation El of the untreated tube is 20% or more (JIS No. 12

specimen), the cross-section hardness HV(10) after quenching is 350 to 550, the completely reversed plane bending fatigue endurance σf is 500 MPa or more, the fracture appearance transition temperature vTrs in the Charpy impact test is -40°C or less, the four-point bending failure time in 0.1N hydrochloric acid is 200 hours or more, and a decrease in the fatigue life in the corrosion fatigue test is less than 1/2 of the number of cycles of an uncorroded specimen. Therefore, excellent formability, fatigue endurance, low temperature toughness, resistance for hydrogen embrittlement, and corrosion fatigue endurance are exhibited.

Industrial Applicability

~~According to the present invention, it~~It is possible to easily produce a steel for structural parts of automobiles at low cost, the steel having excellent formability, excellent fatigue endurance after quenching, excellent low temperature toughness, excellent resistance for hydrogen embrittlement, and excellent corrosion fatigue endurance which are required for suspension and chassis members.